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Sexual dimorphism in a scarcely dimorphic newt, *Triturus italicus* (Peracca, 1898) (Caudata: Salamandridae)

Abstract – Il dimorfismo sessuale in un tritone poco dimorfico, *Triturus italicus* (Peracca, 1898) (Caudata: Salamandridae).

È stata studiata la variazione della morfologia esterna tra i sessi nel tritone italico, *Triturus italicus* (Peracca, 1898). Su 76 maschi e 135 femmine provenienti da 11 località di tutto l'areale sono state misurate 12 variabili. Per i confronti tra sessi entro ogni popolazione per ogni variabile si sono impiegati sia tests t di Student che l'ANCOVA con la lunghezza punta del muso-margine posteriore della cloaca come variabile indipendente. Le femmine raggiungono dimensioni maggiori e in proporzione hanno valori più grandi della distanza tra la punta del muso e il margine anteriore della cloaca e della distanza tra gli arti, mentre i maschi raggiungono valori proporzionali maggiori per la lunghezza della coda, per quella degli arti, per la distanza tra gli occhi e per quella tra le narici. Le femmine inoltre presentano maggiore variabilità rispetto ai maschi. Un'analisi delle componenti principali suggerisce che il dimorfismo sessuale varia geograficamente.

Riassunto – The variation of the external morphology between sexes in the Italian newt, *Triturus italicus* (Peracca, 1898) was studied. Twelve variables were taken on 76 males and 135 females from 11 localities of the whole distribution area. Comparisons between sexes in each population were performed for each variable by both Student's t tests and ANCOVA with snout-vent length as independent variable to remove the size effect. Females attain larger sizes and proportionally higher values of distance between the tip of the snouth and the anterior margin of the vent and distance between fore and hind limbs. Males have proportionally higher values of the tail length, the length of both the fore and hind limbs, the distance between the eyes and the distance between the nostrils. Furthermore, females have a higher variability than males. A principal component analysis reveals that sexual dimorphism varies geographically.

Key words: Caudata, Salamandridae, *Triturus italicus*, sexual dimorphism.

Introduction

The sexual dimorphism in the newt genus *Triturus* Rafinesque, 1815 is the most pronounced among Caudata (Halliday, 1975). However, the Italian newt, *T. italicus* (Peracca, 1898), endemic to central and southern Italy, seems to be an exception. In the available literature (e.g., Peracca, 1898;

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Boulenger, 1910; Schreiber, 1912; Vandoni, 1914; Capocaccia, 1968; Thorn, 1969; Freytag, 1971; Bruno, 1973; Lanza, 1983; Matz & Weber, 1983; Ballasina, 1984; Arnold & Burton, 1985; Diesener & Reicholf, 1986; Zuffi & Ferri, 1990; Nöllert & Nöllert, 1992; Scillitani et al., 1993) only four characters are reported to be sexually dimorphic, i.e., the total body length (females are larger), the tail length in respect to the snout-vent length (higher in the male, equal to or lower in the female), the presence of a swollen glandular area around the vent in the male, and the shape of the body, whose transverse section appears to be circular in the female and square in the male, due to a ridge running along each side of the back.

In contrast with most of the co-generic species (e.g., Thorn, 1969), the development of secondary sexual characters in *T. italicus* during the breeding season is reduced, since the dorsal fin in the males does not develop and only the tail terminal filament elongates. Also the body coloration does not differ much between sexes and does not change during the active reproductive cycle.

Several authors (e.g., Kminiak, 1971; Šova, 1973; Roček, 1974; Caetano, 1982; Tucič & Kalezič, 1984; Juszczyk & Swierad, 1984) find a significant variation between sexes in a number of body measures, including some, like the total body length, the distance between the fore and the hind limbs and the length of the limbs, which are regarded as diagnostic in the taxonomy of the genus (e.g., Wolterstorff, 1923; Terent'ev & Chernov, 1949). Thus, the knowledge of morphological variation between sexes in a species is of great importance not only to study the reproductive biology and the ontogeny, but also the evolutionary biology and the systematics of the genus *Triturus*.

Little is known about morphological variability in *T. italicus* (Peracca, 1898; Scillitani, 1992; Scillitani et al., 1993; Scillitani & Frisenda, 1993). In this paper the existence and the extent of sexual dimorphism in *T. italicus* will be studied by means of a biometric analysis on the external morphology.

Material and methods

Two hundred and eleven adult individuals (76 males and 135 females) of *T. italicus* were examined. They came from the Museum of Zoology of the University, Florence (MZUF), from the Museum of Vertebrate Zoology, Berkeley, California (MVZB), from the Museum of Zoology of the University «Federico II», Naples (MZUN), and from the private collection of V. Caputo, Naples (HCC). The collecting localities and their abbreviations are:

Ge: Genga (Ancona, Marche Region), Mulattieri, pond, 350 m a.s.l., 4/1983; 5 males, 5 females. (MVZB 192054-192063);

Ag: Agnone (Isernia, Molise Region), Valley of the River Cerro, 900 m a.s.l., 22/4/1982; 5 mm., 6 ff. (MVZB without numbers);

Ep: Epitaffio (Campobasso, Molise Region), along the road to Vinchiaturo, 520 m a.s.l., 24/4/1973; 9 mm., 15 ff. (MZUF 9262-9264; 9266-9286);

Gr: Grazzanise (Caserta, Campania Region), 29/5/1972; 5 mm., 9 ff. (MZUF 8655-8669);

La: Laurino (Salerno, Campania Region), tank, 700 m a.s.l. 8 mm., 6/4/1986; 23 ff. (HCC 84-87; 179-198; 228-233; 276-277);

Ce: Casal Velino (Salerno, Campania Region), connected tanks, 150 m a.s.l., 5/1983; 4 mm., 5 ff. (MVZB 192035-192043);

LL: Lake Laudemio, Lagonegro (Potenza, Basilicata Region), 1525 m a.s.l., 20/5/1972; 2 mm., 17 ff. (MZUF 8870-8887);

DU: Lake Due Uomini, Fagnano Castello (Cosenza, Calabria Region), 1080 m a.s.l., 18/4/1990; 13 mm., 20 ff. (MZUN 1056-1089);

SS: Santa Severina (Catanzaro, Calabria Region), tank, 200 m. a.s.l., 20/4/1990; 8 mm., 5 ff. (MZUN 1043-1053);

SL: San Luca (Reggio Calabria, Calabria Region), left tributary of the Bonamico River, 300 m a.s.l., 16/6/1989; 3 mm., 9 ff. (MZUN 1009-1020);

Pa: Palizzi (Reggio Calabria, Calabria Region), River Palizzi, 280 m a.s.l., 11/6/1877, 15/6/1989, and 19/4/1990; 14 mm., 21 ff (MZF 6159-6162; MZUN 1021-1030, and MZUN 1090-1110, respectively).

Eigth of the most common variables used to study the external morphology in the genus *Triturus* (e.g., Tucič & Kalezič, 1984; Opatrný, 1992) were taken (Fig. 1), i.e.: 1) Lsv: snout-vent length, from the tip of the snout to the posterior margin of the cloacal slit; 2) Lcd: tail length, from the insertion of the hind limb to the tip, excluding the terminal filament because it was damaged in several specimens, and its length is reported to vary in the males according to the reproductive cycle (Thorn, 1969); 3) Lcp: length from the tip of the snout to anterior margin of the cloacal slit; 4) Ltc: maximum width of the head; 5) Lc: length of the head, from the tip of the snout to the gular fold; 6) Pa: length of the fore limb, from the body insertion to the tip of the third digit; 7) Pp: length of the hind limb, from the body insertion to the tip of the third digit; 8) D: distance between the fore and the hind limbs. Four further measures were taken on the head, i.e., 9) Dno: distance between the posterior margin of the nostril and the anterior margin of the eye; 10) Dmo: maximum diameter of the eye; 11) Do: minimum distance between the eyes; 12) Din: minimum distance between the nostrils. Measures 1 to 8 were taken by a hand-held dial calliper and measures 9 to 12 under a stereomicroscope at 10× to the nearest 0.1 mm.

The data were converted to natural logarithms for further computations. This transformation usually renders the relations between variables linear (e.g., Thorpe, 1976; Marcus, 1990), particularly in presence of allometric growth (e.g., Jolicoeur, 1963; Gould, 1966), reported in *Triturus* species by Rehák (1983). The most common descriptive statistics (mean, standard deviation, coefficient of variation; e.g., Camussi et al., 1986) were estimated separately for males and females from each samples. The means of each variable were compared between sexes in each population by Student's t-tests. Since Pa in the two males from LL did not vary, a modified t-test to compare a single value of a sample with the mean of another one was used (Sokal & Rohlf, 1981, p. 230). The means in each population were also compared by an analysis of covariance (ANCOVA) with Lsv as independent variable in order to estimate the effects due to differences in body size between sexes. For each analysis the value of the estimated probability to reject the null hypothesis was set to $\alpha < 0.05$.

The differences between sexes were also represented by a principal component analysis (PCA) on Pearson's product-moment correlation coefficients between standardized means of variables. The first three principal

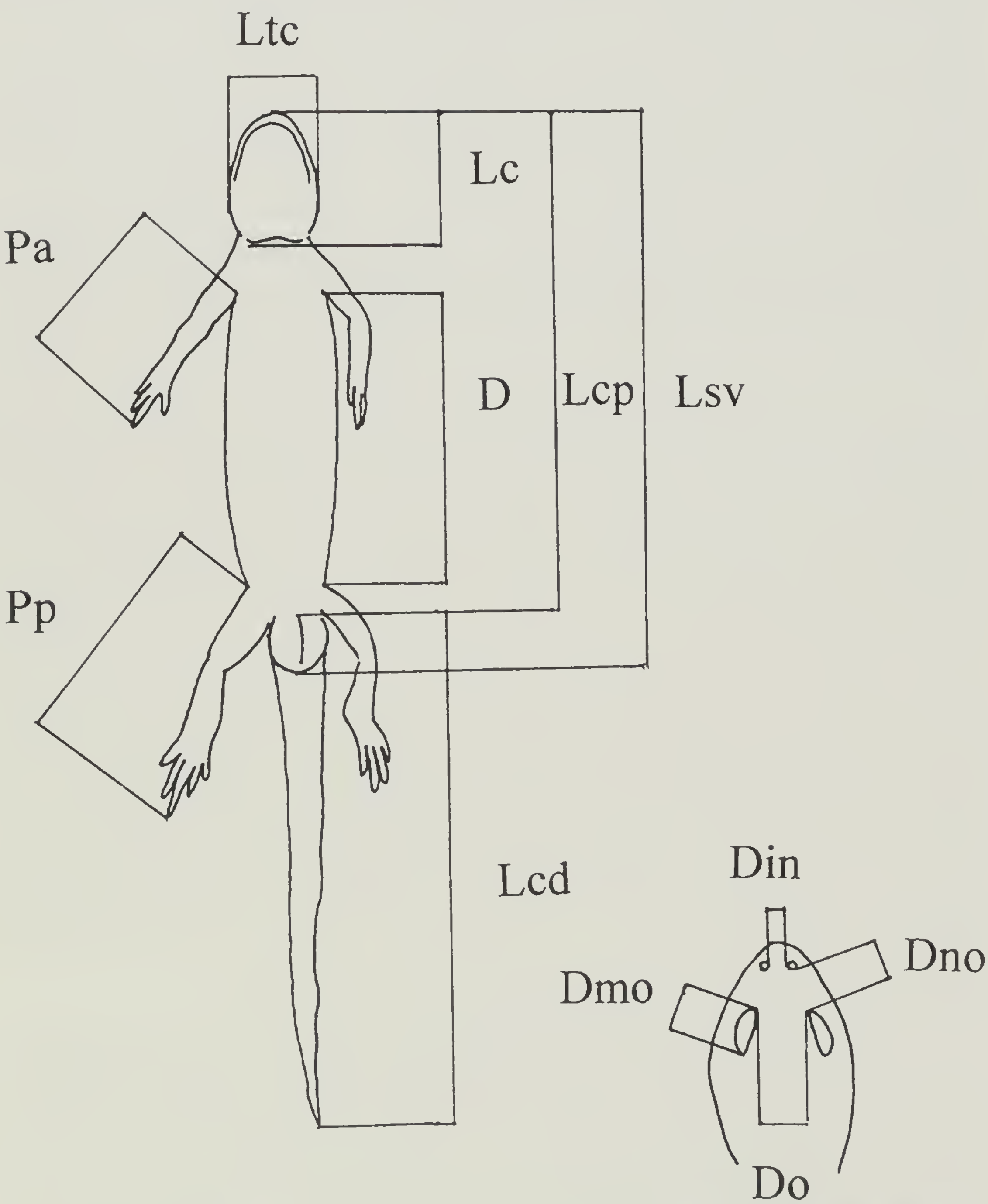

Fig. 1 - Variables measured for the morphological analysis in *Triturus italicus*. See the text for the abbreviations.

component scores of each sample were used to make three two-dimensional scatter plots. An inter-OTU matrix of Euclidean distances was computed from the principal component scores; from this, a minimum spanning tree (MST; e.g., Sneath & Sokal, 1973) was computed to connect all the OTUs in the plots to detect local distorsions.

For the statistical computations the packages SYSTAT 5.0 e NTSYS 1.6 were used.

Results

The descriptive statistics of the 12 variables and the results of Student's t-tests between sexes in each population are in Tab. I. Values of Lcd (except for Ep), Lcp, Ltc, Lc (except for SS), and D are always higher in the females, whereas no general trends are observed in the other variables. Variation coefficients are larger in the females in most of the cases. Values of Lsv, Lcp, Ltc, Lc e D are significantly different between sexes in most of the comparisons, and in the others the computed probability values are in any case near to the limit of 0.05. The null hypothesis is rejected in three comparisons of Lcd, Dno, Do and Din, in only one of Pa and Dmo and none of Pp.

The results of the ANCOVA between sexes with Lsv as the independent variable are in Tab. II. In most of the comparisons, and in all the significantly different ones, Lcd, Pa, Pp, Do and Din are higher in the males, while Lcp and D are higher in the females.

Pearson's moment-product correlation coefficients between standardized means of variables are in Tab. III. The eigenvalues of the three first PCs extracted from the correlation matrix removed respectively 71.70%, 9.95%, and 6.10% of the total variance. The eigenvectors associated to the 12 PCs are in Tab. 4: they all have high, positive values in the 1st PC, whereas they have mixed signs in the 2nd and the 3rd PC, the absolute higher values being observed for Dno, Dmo e Do in the 2nd PC and for Lcp, D, Pp, Dno e Din in the 3rd. Figs 2 e 3 represent the plots of the 1st PC against the 2nd one, and of the 2nd PC against the 3rd one in a two-dimensional Euclidean space. OTU in Fig. 2 are connected by a MST, omitted for simplicity in Fig. 3. Males from each population are always distinct from females and have lower scores on the 1st and 3rd PC (except for the scores of Ag on the 1st PC), and higher ones on the 2nd PC. Tab. V are the Euclidean distances computed from all the 12 PC projection scores between sexes from each population: these values differs from one population to another, the highest one (La) being three times the lowest one (SS). The MST does not always link together the sexes in each population, nor all the males or females from different populations.

Discussion

The females of *T. italicus* have a higher variability than males in each population, as already observed by Scillitani & Frisenda (1993) in *T. italicus* from Apulia, southern Italy, and by Kalezič & Tucič (1984) in *T. vulgaris* (L., 1758) from the Balkan Peninsula. A number of factors can affect morphological variability in *Triturus* species, such as population diversified genetic structure (e.g., Rafinski, 1974), hydrobiological features of the pond and also abiotic factors, like sudden recurrence of the cold or the warm seasons, or long-lasting droughts that can influence the number of the larvae and their growth (Juszczyk & Swierad, 1984; Atkinson, 1994); the growth rate prior of the age of the first breeding is a significant source of variation in *T. vulgaris* as well as in many amphibians and reptiles (Halliday & Verrell, 1988). The causes of the different amount of variability between sexes however are not clear: according to Tucič & Kalezič (1984) males would meet higher developmental constraints reducing variation; furthermore, they observed that the males of smooth newt in their study are older than females and the reduction in variation could also have been caused by stabilizing selection, as Bell (1974, 1978) invoked to explain the decrease of morphological variability during the larval life in *T. vulgaris*. It should be noted that Tucič & Kalezič (1984) estimate the age of each specimen from the body length; thus, the males of *T. italicus* in the present study would be generally younger then females, but their variability is still lower. Halliday & Verrell (1988) however do not find any correlation between age and size in newts and in other amphibians. A different variability in the samples can be a problem in choosing the kind of statistic test to analyze differences among samples: parametric tests, such as Student t-test, ANOVA and ANCOVA, require equal sample variances (e.g., Sokal & Rohlf, 1981); howe-

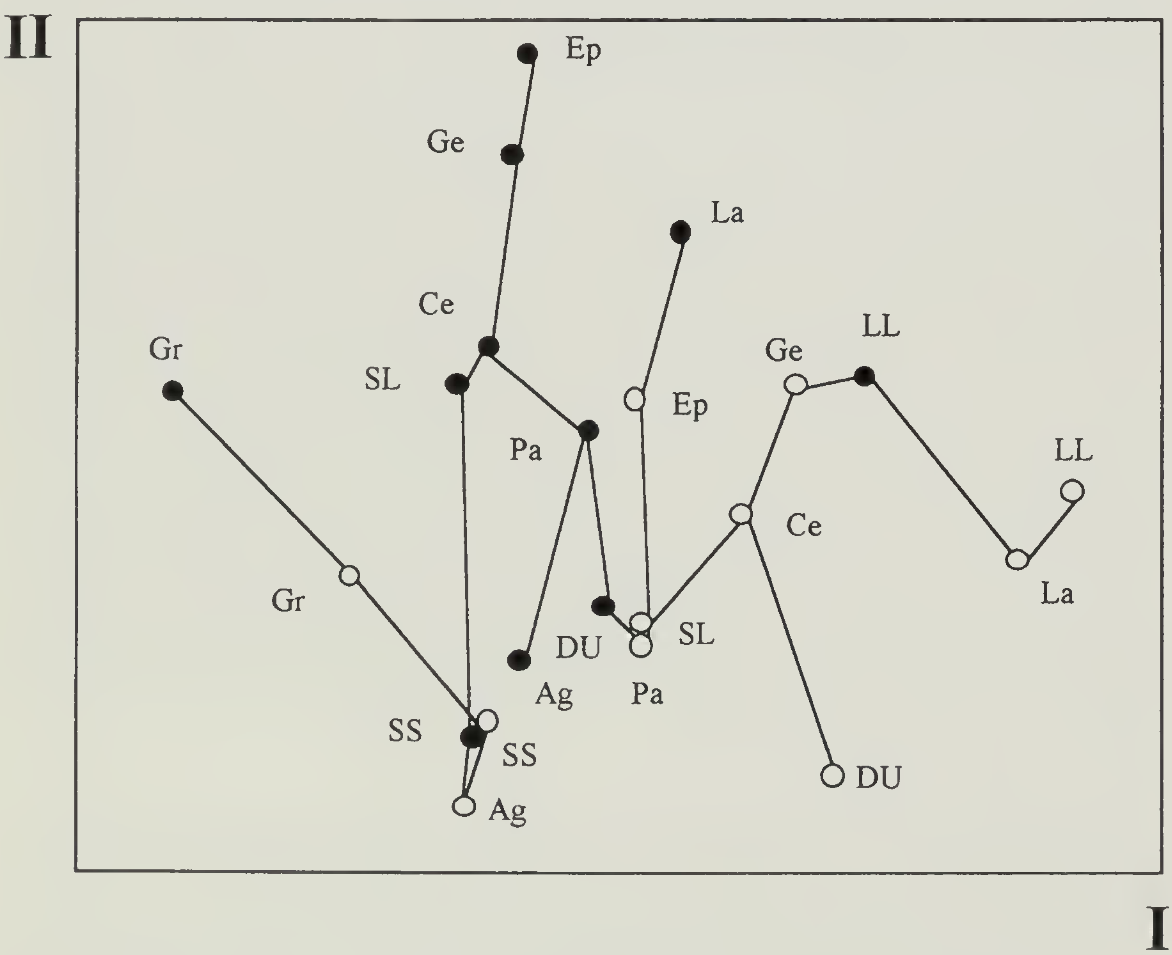

Fig. 2 - Projections in a two-dimensional Euclidean space of the first two principal components of each male (●) and female (○) sample in 11 populations of *Triturus italicus*. The OTUs are linked by a minimum spanning tree. See the text for further explainations.

ver, the logarithmic transformation of the data rendered the male and female samples homoscedastic in most of the populations, as confirmed by preliminar Bartlett's tests. In any case, even if the variances are heterogeneous, parametric tests result quite robust, if the null hypothesis is rejected (e.g., Camussi et al., 1986).

Having found a significant difference in body size between sexes in most of the populations, it was necessary to remove the effect due to size in the comparisons: the traditional method of ratios was avoided because a number of statistic problems arise in their use (e.g., Atchley et al., 1976; Sokal & Rohlf, 1981; Marcus, 1990). Furthermore, according to Atchley et al. (1976), the use of ratios does not remove totally the size effect; thus, in this study ANCOVA with Lsv as the independent variable was preferred (e.g., Thorpe, 1976). The results obtained by Student's t-tests and ANCOVA are rather different: Lcd and Do were higher in the females in the tests without size correction, whereas they resulted to be higher in the males after size correction; Lcp and D were not influenced by size correction and resulted always higher in the females; higher values of Ltc and Lc were found in the females, but this trend disappeared after size correction; by contrast, Pa, Pp and Din tended to be higher in the males only after correction.

A proportionally longer tail in the males has been already observed by

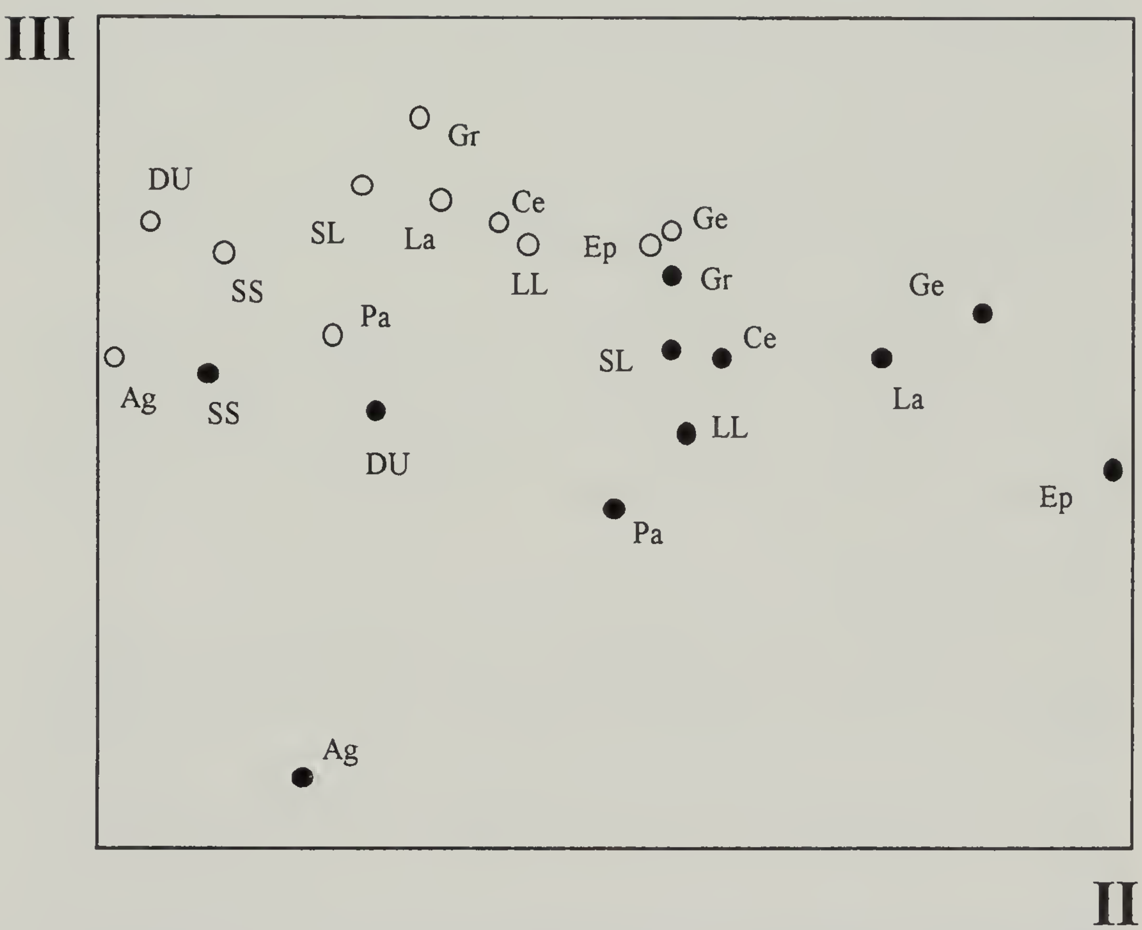

Fig. 3 - Projections in a two-dimensional Euclidean space of the second and third principal components of each male (●) and female (○) sample in 11 populations of *Triturus italicus*. See the text for further explainations.

Peracca (1898). Scillitani & Frisenda (1993) compared the sexes by ANCOVA in a population of large-sized *T. italicus* from Martina Franca (Taranto, Apulia Region) and found higher values of Lcp and D in the females and higher values of Pa and Pp in the males. Differences between sexes in Lcp and D are probably linked to different development of the vent.

PCA well underlines the effect of size. The 1st PC accounts for most of the variance: since the associated eigenvector has all high, positive values, this PC can be regarded as a measure of «size» (e.g., Jolicoeur & Mosimann, 1960). Tucič & Kalezič (1984) obtain a similar result from a PCA on *T. vulgaris* and conclude that the principal cause of variation between sexes is due to size. By contrast, the next two eigenvectors have mixed signs; in traditional morphometrics these PC would be regarded as measures of «shape»: in particular, since in the 2nd PC higher values are observed for coefficients of head variables, this would be considered a measure of the «shape of the head», whereas the 3rd PC represents a measure of the «shape of the body». On the latter PC, males have usually lower scores. It should be noted, however, that Marcus (1990) considers this interpretation of «size» and «shape» of PCs a too simplistic one, since the requirements of uncorrelation of scores among PCs and orthogonality of eigenvectors renders necessarily each eigenvector a mixture of signs («shape») if one of them has all signs the same («size»). Reyment (1990) suggests that the traditional assumption of «size» and «shape» can be maintained if the first two eigenvectors account for most of the original variation, as in the present case.

The PCA analysis and the Euclidean distances between sexes underline a geographic variation of the extent of the sexual dimorphism. A casual deviation cannot be excluded, however, due to the small size of some samples. Furthermore, the variation among samples of the same sex is higher than that between sexes: this results in a overlapping of the total male and female samples, as evidenced by the MST.

In conclusion, outer morphology in *T. italicus* is variable between sexes because of the different proportional development of the body parts. A number of variables used as diagnostic tools in *Triturus* taxonomy appear to vary significantly between sexes and are influenced at least by two other factors, i.e., size and geographic location. Consequently, one should carefully consider these sources of variation in taxonomic studies based on these widely employed variables.

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Table I - Descriptive statistics and Student t-tests on 12 morphological variables between sexes in populations of *Triturus italicus*. Abbreviations: C.V. = Coefficient of Variation; m = mean; max = maximum value; min = minimum value; N = Number of individuals; P = Probability associated with t-test; Pop. = Population.

Lsv														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	3.315	0.035	3.270	3.364	1.066	5	3.374	0.089	3.254	3.490	2.647	1.378	0.205
CE	4	3.356	0.015	3.336	3.367	0.441	5	3.510	0.029	3.466	3.541	0.815	9.629	0.000
DU	13	3.416	0.030	3.360	3.466	0.867	20	3.573	0.058	3.472	3.761	1.617	9.023	0.000
Ep	9	3.366	0.030	3.343	3.431	0.893	15	3.447	0.064	3.300	3.538	1.870	3.508	0.002
Ge	3	3.402	0.040	3.346	3.431	1.179	3	3.557	0.072	3.484	3.619	2.029	2.955	0.042
Gr	5	3.201	0.054	3.127	3.273	1.688	9	3.301	0.095	3.157	3.453	2.863	2.161	0.052
La	8	3.454	0.042	3.381	3.517	1.210	23	3.654	0.104	3.437	3.816	2.859	5.239	0.000
LL	2	3.515	0.004	3.512	3.517	0.114	17	3.640	0.085	3.475	3.754	2.330	2.035	0.058
Pa	14	3.385	0.035	3.332	3.437	1.030	21	3.459	0.113	2.996	3.564	3.265	2.353	0.025
SL	3	3.328	0.022	3.296	3.339	0.646	9	3.448	0.077	3.307	3.550	2.227	2.663	0.024
SS	8	3.351	0.053	3.285	3.466	1.576	5	3.398	0.144	3.144	3.484	4.241	0.850	0.414

Lcd														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	3.340	0.061	3.273	3.414	1.816	5	3.308	0.136	3.140	3.469	4.113	0.486	0.640
CE	4	3.337	0.070	3.246	3.408	2.100	5	3.425	0.109	3.239	3.517	3.189	1.401	0.204
DU	13	3.471	0.066	3.381	3.608	1.914	20	3.545	0.051	3.453	3.648	1.438	3.596	0.001
Ep	9	3.466	0.126	3.343	3.750	3.622	15	3.396	0.095	3.165	3.515	2.796	1.540	0.138
Ge	3	3.401	0.042	3.350	3.453	1.236	3	3.528	0.127	3.405	3.638	3.613	1.126	0.323
Gr	5	3.184	0.098	3.025	3.266	3.081	9	3.273	0.101	3.082	3.453	3.074	1.589	0.138
La	8	3.439	0.076	3.311	3.520	2.224	23	3.626	0.119	3.398	3.846	3.289	4.130	0.000
LL	2	3.578	0.008	3.572	3.584	0.195	17	3.624	0.102	3.374	3.757	2.828	0.614	0.547
Pa	14	3.432	0.060	3.311	3.503	1.760	21	3.441	0.078	3.303	3.605	2.256	0.361	0.720
SL	3	3.352	0.065	3.296	3.414	1.927	9	3.359	0.114	3.148	3.515	3.405	0.164	0.873
SS	8	3.348	0.089	3.239	3.484	2.653	5	3.346	0.210	2.981	3.512	6.263	0.020	0.984

Table I. (continued)

Lcp														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	3.186	0.029	3.157	3.219	0.922	5	3.255	0.090	3.161	3.364	2.776	1.624	0.143
CE	4	3.247	0.010	3.235	3.258	0.301	5	3.421	0.035	3.391	3.466	1.017	9.586	0.000
DU	13	3.286	0.034	3.231	3.346	1.034	20	3.471	0.054	3.378	3.648	1.553	10.951	0.000
Ep	9	3.189	0.036	3.122	3.254	1.134	15	3.351	0.080	3.174	3.456	2.392	5.690	0.000
Ge	3	3.284	0.077	3.170	3.343	2.355	3	3.449	0.081	3.350	3.515	2.352	2.123	0.101
Gr	5	3.071	0.106	2.976	3.195	3.457	9	3.211	0.081	3.086	3.346	2.534	2.779	0.017
La	8	3.325	0.047	3.250	3.381	1.402	23	3.563	0.106	3.339	3.728	2.987	6.087	0.000
LL	2	3.379	0.012	3.367	3.391	0.355	17	3.555	0.083	3.388	3.689	2.339	2.915	0.010
Pa	14	3.267	0.035	3.203	3.325	1.076	21	3.355	0.128	2.821	3.459	3.830	2.490	0.018
SL	3	3.220	0.028	3.186	3.254	0.862	9	3.409	0.069	3.314	3.493	2.038	4.443	0.001
SS	8	3.205	0.071	3.122	3.360	2.230	5	3.305	0.145	3.054	3.398	4.388	1.688	0.120

Ltc														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	1.605	0.043	1.569	1.668	2.679	5	1.608	0.063	1.526	1.686	3.935	0.092	0.929
CE	4	1.662	0.052	1.609	1.723	3.145	5	1.835	0.082	1.740	1.917	4.446	3.659	0.008
DU	13	1.672	0.054	1.569	1.758	3.205	20	1.817	0.047	1.740	1.902	2.591	8.181	0.000
Ep	9	1.729	0.066	1.609	1.792	3.809	15	1.801	0.062	1.609	1.872	3.421	2.723	0.012
Ge	3	1.612	0.073	1.526	1.705	4.538	3	1.766	0.041	1.705	1.792	2.347	2.474	0.069
Gr	5	1.539	0.025	1.504	1.569	1.610	9	1.645	0.065	1.548	1.792	3.943	3.465	0.005
La	8	1.755	0.035	1.686	1.792	1.970	23	1.967	0.103	1.758	2.116	5.229	5.657	0.000
LL	4	1.887	0.021	1.872	1.902	1.113	17	2.023	0.102	1.841	2.128	5.021	1.848	0.082
Pa	14	1.625	0.043	1.569	1.686	2.654	21	1.684	0.038	1.609	1.740	2.234	4.250	0.000
SL	3	1.617	0.081	1.548	1.705	5.032	9	1.710	0.075	1.569	1.808	4.375	1.380	0.198
SS	8	1.642	0.063	1.569	1.758	3.839	5	1.671	0.146	1.411	1.758	8.768	0.497	0.629

Lc														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	1.919	0.033	1.887	1.974	1.717	5	1.915	0.068	1.841	2.001	3.540	0.129	0.901
CE	4	1.979	0.062	1.902	2.041	3.118	5	2.090	0.072	2.001	2.186	3.466	2.417	0.046
DU	13	1.993	0.067	1.856	2.067	3.379	20	2.096	0.070	1.974	2.241	3.330	4.206	0.000
Ep	9	1.924	0.080	1.792	2.015	4.138	15	2.023	0.100	1.792	2.140	4.939	2.538	0.019
Ge	3	1.941	0.058	1.856	1.988	2.998	3	2.106	0.055	2.041	2.152	2.628	3.029	0.039
Gr	5	1.870	0.107	1.723	1.960	5.740	9	1.971	0.077	1.856	2.079	3.911	2.049	0.063
La	8	2.044	0.060	1.960	2.104	2.939	23	2.225	0.112	2.028	2.407	5.032	4.307	0.000
LL	2	2.169	0.008	2.163	2.175	0.369	17	2.251	0.101	2.054	2.434	4.502	1.122	0.278
Pa	14	1.967	0.088	1.825	2.163	4.463	21	1.983	0.083	1.808	2.140	4.192	0.518	0.608
SL	3	1.913	0.141	1.705	2.001	7.382	9	2.056	0.097	1.902	2.208	4.712	2.304	0.044
SS	8	1.964	0.065	1.841	2.054	3.286	5	1.881	0.088	1.740	1.960	4.653	1.964	0.075

Table I. (continued)

Pa

Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	2.355	0.077	2.251	2.460	3.261	5	2.345	0.107	2.251	2.526	4.569	0.170	0.869
CE	4	2.432	0.065	2.351	2.485	2.686	5	2.486	0.078	2.351	2.542	3.152	1.102	0.307
DU	13	2.440	0.051	2.361	2.518	2.084	20	2.465	0.053	2.380	2.610	2.157	1.331	0.193
Ep	9	2.404	0.042	2.351	2.485	1.734	15	2.379	0.087	2.197	2.485	3.668	0.802	0.431
Ge	3	2.411	0.041	2.351	2.442	1.686	3	2.511	0.087	2.398	2.580	3.485	1.368	0.243
Gr	5	2.222	0.054	2.140	2.272	2.416	9	2.228	0.091	2.079	2.303	4.084	0.117	0.909
La	8	2.556	0.075	2.416	2.639	2.918	23	2.596	0.099	2.351	2.760	3.800	1.045	0.305
LL	2	2.565	0.000	2.565	2.565	0.000	17	2.619	0.093	2.460	2.773	3.537	0.564[1]	0.580
Pa	14	2.431	0.055	2.351	2.588	2.250	21	2.392	0.054	2.303	2.485	2.276	2.085	0.045
SL	3	2.351	0.094	2.272	2.460	4.004	9	2.392	0.124	2.251	2.639	5.201	0.193	0.851
SS	8	2.298	0.070	2.219	2.407	3.035	5	2.275	0.191	1.946	2.407	8.390	0.316	0.758

Pp

Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	2.482	0.302	2.262	3.011	12.176	5	2.369	0.085	2.282	2.485	3.584	0.802	0.446
CE	4	2.413	0.035	2.370	2.442	1.465	5	2.453	0.050	2.370	2.485	2.046	1.352	0.218
DU	13	2.457	0.073	2.303	2.549	2.963	20	2.454	0.047	2.380	2.549	1.926	0.162	0.872
Ep	9	2.446	0.055	2.351	2.526	2.269	15	2.404	0.093	2.197	2.526	3.861	1.215	0.237
Ge	3	2.459	0.041	2.398	2.485	1.686	3	2.522	0.093	2.442	2.603	3.685	0.762	0.489
Gr	5	2.274	0.141	2.116	2.442	6.194	9	2.216	0.114	1.946	2.303	5.163	0.845	0.415
La	8	2.550	0.059	2.485	2.639	2.320	23	2.573	0.115	2.197	2.766	4.484	0.543	0.591
LL	2	2.602	0.052	2.565	2.639	1.998	17	2.623	0.098	2.442	2.803	3.749	0.287	0.777
Pa	14	2.436	0.070	2.303	2.542	2.885	21	2.402	0.068	2.230	2.518	2.813	1.440	0.159
SL	3	2.371	0.059	2.322	2.442	2.504	9	2.379	0.071	2.262	2.485	2.969	0.178	0.862
SS	8	2.317	0.102	2.219	2.477	4.402	5	2.347	0.145	2.116	2.493	6.192	0.448	0.663

D

Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	2.495	0.070	2.398	2.588	2.788	5	2.651	0.109	2.510	2.760	4.121	2.703	0.027
CE	4	2.555	0.039	2.510	2.588	1.540	5	2.798	0.059	2.728	2.879	2.112	7.017	0.000
DU	13	2.631	0.078	2.485	2.773	2.977	20	2.852	0.092	2.695	3.122	3.243	7.109	0.000
Ep	9	2.483	0.068	2.425	2.646	2.736	15	2.693	0.092	2.485	2.845	3.401	5.965	0.000
Ge	3	2.629	0.034	2.580	2.660	1.310	3	2.797	0.028	2.773	2.821	0.990	5.609	0.005
Gr	5	2.381	0.104	2.282	2.501	4.381	9	2.565	0.127	2.361	2.701	4.952	2.749	0.018
La	8	2.640	0.069	2.565	2.773	2.612	23	2.929	0.122	2.708	3.186	4.151	6.349	0.000
LL	2	2.721	0.019	2.708	2.734	0.698	17	2.941	0.108	2.721	3.109	3.680	2.803	0.012
Pa	14	2.598	0.074	2.451	2.708	2.840	21	2.732	0.080	2.573	2.874	2.912	5.001	0.000
SL	3	2.591	0.080	2.485	2.653	3.092	9	2.747	0.089	2.653	2.890	3.225	3.017	0.013
SS	8	2.602	0.194	2.313	2.944	7.462	5	2.691	0.205	2.342	2.851	7.619	0.793	0.445

[1] Student's t-test modified to compare the female mean with a single value in the male sample, since no variation was found (Sokal & Rohlf, 1981)

Table I. (continued)

Dno														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	0.838	0.086	0.693	0.916	10.307	5	0.762	0.140	0.588	0.956	18.329	1.040	0.329
CE	4	0.654	0.064	0.588	0.742	9.833	5	0.751	0.040	0.693	0.788	5.272	2.808	0.026
DU	13	0.799	0.079	0.642	0.956	9.868	20	0.820	0.093	0.693	1.065	11.375	0.653	0.519
Ep	9	0.559	0.090	0.405	0.693	16.039	15	0.690	0.118	0.531	0.875	17.062	2.856	0.009
Ge	3	0.580	0.142	0.470	0.788	24.417	3	0.728	0.073	0.642	0.788	9.978	1.045	0.355
Gr	5	0.492	0.083	0.405	0.588	16.821	9	0.568	0.227	0.405	1.099	39.926	0.718	0.487
La	8	0.683	0.088	0.531	0.788	12.921	23	0.871	0.075	0.693	0.993	8.582	5.838	0.000
LL	2	0.763	0.099	0.693	0.833	12.975	17	0.812	0.110	0.588	0.993	13.609	0.593	0.561
Pa	14	0.772	0.084	0.642	0.875	10.947	21	0.761	0.086	0.642	0.916	11.370	0.382	0.705
SL	3	0.500	0.063	0.405	0.531	12.613	9	0.685	0.206	0.405	1.099	30.072	1.574	0.147
SS	8	0.744	0.089	0.642	0.875	11.906	5	0.666	0.131	0.470	0.833	19.620	1.295	0.222

Dmo														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	0.708	0.110	0.588	0.875	15.477	5	0.596	0.083	0.470	0.693	13.915	1.818	0.107
CE	4	0.680	0.026	0.642	0.693	3.749	5	0.680	0.093	0.531	0.788	13.640	0.013	0.990
DU	13	0.804	0.102	0.588	0.956	12.661	20	0.835	0.096	0.693	1.030	11.524	0.870	0.391
Ep	9	0.910	0.052	0.788	0.993	5.764	15	·0.794	0.088	0.693	0.916	11.146	3.581	0.002
Ge	3	0.723	0.138	0.588	0.916	19.124	3	0.860	0.112	0.693	0.916	12.961	0.897	0.421
Gr	5	0.662	0.047	0.588	0.693	7.071	9	0.709	0.047	0.693	0.833	6.586	1.798	0.097
La	8	0.858	0.055	0.788	0.916	6.448	23	0.874	0.098	0.693	1.099	11.176	0.441	0.662
LL	2	0.875	0.059	0.833	0.916	6.742	17	0.924	0.114	0.693	1.099	12.294	0.599	0.557
Pa	14	0.836	0.111	0.642	0.993	13.281	21	0.810	0.093	0.642	0.916	11.451	0.764	0.451
SL	3	0.820	0.064	0.788	0.916	7.805	9	0.864	0.076	0.693	0.916	8.747	0.650	0.530
SS	8	0.687	0.116	0.470	0.833	16.848	5	0.623	0.225	0.262	0.833	36.204	0.691	0.504

Do														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	0.945	0.088	0.833	1.065	9.309	5	0.890	0.064	0.788	0.956	7.179	1.119	0.296
CE	4	0.726	0.102	0.588	0.833	13.998	5	0.790	0.139	0.642	0.956	17.573	0.763	0.470
DU	13	0.921	0.060	0.833	1.030	6.508	20	1.021	0.059	0.875	1.131	5.827	4.718	0.000
Ep	9	0.745	0.064	0.693	0.833	8.580	15	0.763	0.145	0.405	0.993	18.990	0.354	0.726
Ge	3	0.626	0.081	0.531	0.693	12.856	3	0.828	0.108	0.693	0.916	13.099	2.435	0.072
Gr	5	0.740	0.066	0.693	0.833	8.959	9	0.810	0.170	0.531	0.993	20.974	0.875	0.399
La	8	0.798	0.125	0.693	0.993	15.712	23	0.925	0.116	0.693	1.099	12.581	2.611	0.014
LL	2	0.936	0.028	0.916	0.956	2.991	17	0.984	0.121	0.788	1.131	12.265	0.553	0.588
Pa	14	0.821	0.114	0.642	0.993	13.912	21	0.915	0.138	0.588	1.099	15.057	2.124	0.041
SL	3	0.896	0.024	0.875	0.916	2.643	9	0.932	0.064	0.875	1.099	6.886	0.757	0.467
SS	8	0.904	0.074	0.833	1.065	8.166	5	0.868	0.140	0.642	0.993	16.085	0.612	0.553

Table I. (continued)

Din														
Pop.	Males						Females						t-test	P
	N	m	s.d.	min	max	C.V.	N	m	s.d.	min	max	C.V.		
Ag	5	0.456	0.246	0.262	0.875	53.985	5	0.175	0.133	0.000	0.336	75.897	2.245	0.055
CE	4	0.242	0.040	0.182	0.262	16.529	5	0.430	0.056	0.405	0.531	13.098	5.636	0.001
DU	13	0.134	0.218	-0.105	0.470	162.697	20	0.307	0.152	0.000	0.693	49.452	2.698	0.011
Ep	9	0.309	0.082	0.182	0.405	26.426	15	0.344	0.122	0.000	0.531	35.640	0.750	0.461
Ge	3	0.309	0.153	0.182	0.531	49.335	3	0.335	0.072	0.262	0.405	21.400	0.085	0.936
Gr	5	-0.064	0.237	-0.357	0.262	373.405	9	0.050	0.238	-0.357	0.405	475.124	0.857	0.408
La	8	0.247	0.185	0.000	0.531	74.926	23	0.434	0.139	0.095	0.642	32.026	3.001	0.005
LL	2	0.438	0.046	0.405	0.470	10.502	17	0.514	0.201	0.262	0.993	39.069	0.524	0.607
Pa	14	0.325	0.153	0.000	0.642	47.149	21	0.301	0.153	0.000	0.588	50.722	0.460	0.649
SL	3	0.250	0.179	0.095	0.405	71.591	9	0.226	0.152	0.000	0.405	67.250	0.720	0.488
SS	8	0.201	0.229	-0.105	0.405	113.696	5	0.244	0.299	-0.223	0.588	122.572	0.292	0.775

Table II - Mean values of 11 variables corrected by analyses of covariance against snout-vent length (Lsv) in populations of *Triturus italicus*, with computed Fisher's F-values between sexes and associated probabilities.

Lcd				
Pop.	Males	Females	F	P
Ag	3.3795	3.2681	8.288	0.024
Ce	3.6254	3.1943	9.178	0.023
DU	3.5253	3.5099	0.204	0.655
Ep	3.5140	3.3674	8.350	0.009
Ge	3.5088	3.3838	3.820	0.146
Gr	3.2564	3.2136	0.457	0.513
La	3.5706	3.5801	0.047	0.830
LL	3.6921	3.6103	3.049	0.100
Pa	3.4457	3.4324	0.272	0.606
SL	3.4817	3.3216	7.060	0.026
SS	3.3700	3.3101	1.469	0.253

Ltc				
Pop.	Males	Females	F	P
Ag	1.6247	1.5879	3.008	0.126
Ce	1.8844	1.6565	5.727	0.054
DU	1.7321	1.7781	2.891	0.099
Ep	1.7644	1.7800	0.340	0.566
Ge	1.6626	1.7081	0.213	0.676
Gr	1.6297	1.5659	4.841	0.050
La	1.8770	1.9249	2.679	0.113
LL	2.0121	2.0089	0.009	0.924
Pa	1.6283	1.6821	12.890	0.001
SL	1.7169	1.6849	0.477	0.507
SS	1.6600	1.6418	0.997	0.000

Lcp				
Pop.	Males	Females	F	P
Ag	3.2128	3.2280	0.592	0.467
Ce	3.3104	3.3695	1.129	0.329
DU	3.3714	3.4155	12.588	0.001
Ep	3.2449	3.3175	20.163	0.000
Ge	3.3684	3.3326	0.260	0.646
Gr	3.1763	3.1335	2.289	0.158
La	3.4713	3.5121	7.445	0.011
LL	3.4871	3.5432	14.429	0.002
Pa	3.3154	3.3229	0.584	0.451
SL	3.2871	3.3867	7.648	0.022
SS	3.2238	3.2752	11.584	0.007

Lc				
Pop.	Males	Females	F	P
Ag	1.9407	1.8937	9.617	0.017
Ce	1.9732	2.0946	0.421	0.540
DU	2.0536	2.0569	0.006	0.938
Ep	1.9794	1.9903	0.089	0.769
Ge	2.0009	2.0244	0.207	0.680
Gr	1.9506	1.9079	0.714	0.416
La	2.1708	2.1806	0.065	0.801
LL	2.2932	2.2371	3.227	0.091
Pa	1.9808	1.9738	0.052	0.822
SL	1.9946	2.0187	0.122	0.735
SS	1.9732	1.8657	10.884	0.008

Table II - (continued)

Pa				
Pop.	Males	Females	F	P
Ag	2.3853	2.3141	2.440	0.162
Ce	2.4701	2.4555	0.005	0.945
DU	2.5121	2.4178	13.886	0.001
Ep	2.4437	2.3554	7.255	0.014
Ge	2.4772	2.4165	0.743	0.452
Gr	2.2121	2.2501	0.594	0.457
La	2.6616	2.5591	7.116	0.013
LL	2.6612	2.6073	1.267	0.277
Pa	2.4400	2.3859	7.743	0.009
SL	2.4432	2.3696	0.545	0.479
SS	2.3150	2.2476	1.524	0.245

Dno				
Pop.	Males	Females	F	P
Ag	0.8747	0.7261	6.094	0.043
Ce	0.6711	0.7365	0.233	0.646
DU	0.8894	0.7613	6.205	0.019
Ep	0.6232	0.6516	0.406	0.531
Ge	0.6690	0.6350	0.032	0.869
Gr	0.5403	0.5427	0.000	0.987
La	0.7456	0.8492	6.879	0.014
LL	0.8462	0.8022	0.316	0.582
Pa	0.7819	0.7540	0.794	0.380
SL	0.6992	0.6146	0.835	0.385
SS	0.7568	0.6461	4.824	0.053

Pp				
Pop.	Males	Females	F	P
Ag	2.5249	2.6211	2.276	0.175
Ce	2.5752	2.7820	0.118	0.743
DU	2.7469	2.7760	8.849	0.006
Ep	2.5458	2.6557	4.630	0.001
Ge	2.6612	2.7542	8.855	0.008
Gr	2.5339	2.4360	1.459	0.252
La	2.8027	2.8723	7.374	0.011
LL	2.8543	2.9261	4.760	0.044
Pa	2.6198	2.7172	3.325	0.078
SL	2.6485	2.7206	4.880	0.055
SS	2.6264	2.6514	0.000	0.998

Dmo				
Pop.	Males	Females	F	P
Ag	0.7193	0.5849	3.650	0.098
Ce	0.6788	0.6807	0.000	0.994
DU	0.8238	0.8224	0.001	0.981
Ep	0.9317	0.7808	14.389	0.001
Ge	0.8254	0.7486	0.127	0.745
Gr	0.6995	0.6782	0.567	0.467
LA	0.9103	0.8563	1.260	0.271
LL	0.9843	0.9111	1.200	0.289
Pa	0.8539	0.7981	2.462	0.126
SL	0.8706	0.8503	0.106	0.752
SS	0.7067	0.5917	2.126	0.175

D				
Pop.	Males	Females	F	P
Ag	2.5249	2.6211	4.639	0.068
Ce	2.5752	2.7820	2.160	0.192
DU	2.7469	2.7760	0.431	0.516
Ep	2.5458	2.6557	17.382	0.000
Ge	2.6612	2.7542	7.376	0.073
Gr	2.5339	2.4360	2.188	0.167
La	2.8027	2.8723	7.536	0.010
LL	2.8541	2.9260	4.672	0.046
Pa	2.6198	2.7172	16.494	0.000
SL	2.6485	2.7206	1.460	0.258
SS	2.6264	2.6514	0.076	0.788

Do				
Pop.	Males	Females	F	P
Ag	0.9612	0.8736	3.076	0.123
Ce	0.9116	0.6415	0.754	0.419
DU	0.8302	0.9087	0.873	0.357
Ep	0.7773	0.7441	0.272	0.607
Ge	0.7005	0.7025	0.001	0.982
Gr	0.8075	0.7451	0.401	0.540
La	0.8890	0.8938	0.005	0.942
LL	1.0461	0.9712	1.069	0.317
Pa	0.8302	0.9087	2.639	0.114
SL	0.8796	0.9394	1.352	0.275
SS	0.9213	0.8397	11.410	0.007

Table V - Euclidean distances between sexes in populations of *Triturus italicus*, as computed by the projections from the PCA.

Pop.	D
Ag	0.111
Ce	0.134
DU	0.125
Ep	0.105
Ge	0.142
Gr	0.101
La	0.178
LL	0.107
Pa	0.063
SL	0.109
SS	0.060